was lacking to assess the histopathological correlation of myocardial delayed enhancement in LVNC. In the present study, our findings show that the fibrosis is the histological basis in the delayed enhancement of compacted myocardium; however, it is still unknown which mechanism plays the leading role in the delayed enhancement of noncompacted myocardium.

***Yan Chaowu, PhD, MD**

*Department of Radiology
Fuwai Hospital
167 Beilishi Road
Beijing 100037
China
E-mail: chaowu_yan@yahoo.com.cn

Li Li, PhD
Zhao Shihua, PhD, MD

doi:10.1016/j.jacc.2011.02.053

Please note: This study was approved by the hospital research ethics committee.

REFERENCES

1. Dursun M, Agayev A, Nisli K, et al. MR imaging features of ventricular noncompaction: emphasis on distribution and pattern of fibrosis. Eur J Radiol 2010;74:147–51.
2. Dodd JD, Holmvang G, Hoffmann U, et al. Quantification of left ventricular noncompaction and trabecular delayed hyperenhancement with cardiac MRI: correlation with clinical severity. AJR Am J Roentgenol 2007;189:974–80.
3. Fazio G, Visconti C, D'Angelo L, Novo G, Novo S. Delayed MRI hyperenhancement in noncompaction: sign of fibrosis correlated with clinical severity (letter). AJR Am J Roentgenol 2008;190:W273.
4. Oechslin EN, Attenhofer Jost CH, Rojas JR, Kaufmann PA, Jenni R. Long-term follow-up of 34 adults with isolated left ventricular noncompaction: a distinct cardiomyopathy with poor prognosis. J Am Coll Cardiol 2000;36:493–500.
5. Jenni R, Oechslin E, Schneider J, Attenhofer Jost C, Kaufmann PA. Echocardiographic and pathoanatomical characteristics of isolated left ventricular non-compaction: a step towards classification as a distinct cardiomyopathy. Heart 2001;86:666–71.

Letters to the Editor

Diagnostic Criteria for Percutaneous Coronary Intervention-Related Myocardial Infarction

Time for Revision?

A significant increase of cardiac biomarkers after percutaneous coronary intervention (PCI) is commonplace and is thought to reflect a clinically significant myocardial injury. According to the joint European Society of Cardiology/American College of Cardiology Foundation/American Heart Association/World Heart Federation task force for the redefinition of myocardial infarction (MI), increases of cardiac troponins >3 times the 99th percentile upper reference limit (URL) are designated as percutaneous coronary intervention (PCI)-related MI (type 4a) (1).

We read with interest the article by Lim et al. (2), who concluded that creatine kinase-myocardial band (CK-MB) should be the preferred biomarker when applying the current universal definition of MI to periprocedural injury, because the arbitrary limit of 3 times the 99th percentile URL troponin threshold might be oversensitive and lead to over-diagnosis of MI in as many as 53% of patients (2). A similar conclusion was earlier reached by Locca et al. (3), who reported a lack of substantial agreement between the new universal definition and cardiovascular magnetic resonance for the diagnosis of small-size periprocedural myocardial damage after complex PCI (3). Although the current definition of periprocedural injury based on the >3 times the 99th percentile URL troponin value might, hence, be challenging, especially when using the new highly sensitive assays, Testa et al. (4) carried out a meta-analysis of 15 studies and 7,578 patients, concluding that troponin elevation was observed in 28.7% of patients undergoing PCI, whereas the incidence of PCI-related MI according to the new definition was 14.5% (4). Most importantly, any level of raised troponin was associated with an increased risk of the composite of all-cause death, MI, repeat target vessel PCI, and coronary artery bypass graft surgery.

Taken together, this evidence suggests that the arbitrary limit of 3 times the 99th percentile URL troponin threshold for diagnosing periprocedural injury might be urgently revised, because of 1) the unsatisfactory diagnostic specificity at this low level; and 2) the potentially inaccurate selection of the reference population for calculating the URL (5). Therefore, a higher cut-off—such as that suggested by Lim et al. (i.e., 40 times the 99th percentile)—should be used for diagnosing periprocedural MI. This enhanced threshold not only displays diagnostic performances comparable to that of CK-MB, but also overcomes the use of a double-biomarker approach (i.e., troponin and CK-MB), with a substantial economical saving. Nevertheless, the current threshold has meaningful prognostic implications, so that patients with troponin values between 3 and 40 times the 99th percentile are to be considered at risk of adverse events and should be managed accordingly.

It is also noteworthy that sample stability is critical for troponin testing. Wu et al. (6) recently observed variations in troponin I above the analytical precision cut-off (as measured with a high-sensitivity assay) in 17% of short-term and 33% of long-term storage samples, suggesting that measurements are more accurate when fresh samples are used, suggesting that the definition of the optimal thresholds for both defining an increased risk of adverse events and diagnosing MI after periprocedural injury should be made preferably using fresh samples.

We are actually trapped between the Scylla of the universal definition of MI and the Charybdis of the prognostic implications

of even minor troponin elevations (5). Maybe the time for diagnostic criteria revision is coming.

***Giuseppe Lippi, MD**
Gianfranco Cervellin, MD

*U.O. Diagnostica Ematochimica
Azienda Ospedaliero-Universitaria di Parma
Via Gramsci, 14
Parma 43126
Italy
E-mail: glippi@ao.pr.it OR giuseppe.lippi@univr.it

doi:10.1016/j.jacc.2011.02.058

REFERENCES

1. Thygesen K, Alpert JS, White HD. Universal definition of myocardial infarction. J Am Coll Cardiol 2007;50:2173–95.
2. Lim CCS, van Gaal WJ, Testa L, et al. With the "universal definition," measurement of creatine kinase-myocardial band rather than troponin allows more accurate diagnosis of periprocedural necrosis and infarction after coronary intervention. J Am Coll Cardiol 2011;57:653–61.
3. Locca D, Bucciarelli-Ducci C, Ferrante G, et al. New universal definition of myocardial infarction applicable after complex percutaneous coronary interventions? J Am Coll Cardiol Intv 2010;3:950–8.
4. Testa L, Van Gaal WJ, Biondi Zoccai GG, et al. Myocardial infarction after percutaneous coronary intervention: a meta-analysis of troponin elevation applying the new universal definition. Q J Med 2009;102:369–78.
5. Lippi G, Cervellin G, Plebani M. Sensitive cardiac troponin T assay. N Engl J Med 2010;362:1242.
6. Wu AH, Shea E, Lu QT, et al. Short- and long-term cardiac troponin I analyte stability in plasma and serum from healthy volunteers by use of an ultrasensitive, single-molecule counting assay. Clin Chem 2009;55:2057–9.

Reply

The apparent paradox of discrepant results of biomarker measurements after percutaneous coronary intervention (PCI) has added further confusion to our limited understanding of myocardial injury that occurs during revascularization. In patients with complex multivessel disease, this myocardial injury occurs equally during either coronary artery bypass graft surgery or PCI despite contemporary procedural technique (1). Myocardial injury during PCI may be either adjacent, caused by occlusion of small side branches during stent implantation, or downstream/distal, caused by embolized atheroma/thrombotic material (2).

Our recent data suggest that higher levels of troponin elevation correlate well with creatine kinase-myocardial band (CK-MB) elevation after PCI (3), and we have previously shown that these biomarker elevations reflect areas of myocardial infarction demonstrable with cardiac magnetic resonance imaging (4). However, in patients with lower levels of troponin elevation after PCI, CK-MB is unlikely to be elevated. In these patients, there is limited evidence of systemic inflammation and no evidence of myocardial infarction on magnetic resonance imaging.

When undertaking analyses of the clinical implication of these smaller troponin elevations after PCI, we should exclude the potential bias of the higher troponin elevations, which, in my opinion, have a clear prognostic consequence. Recently, Cavallini et al. (5) have confirmed that smaller elevations of troponin after PCI (when CK-MB is normal) are principally a reflection of the patient's baseline risk profile and that the prognostic impact is marginal. In my opinion, this particular clinical scenario of normal CK-MB with small troponin rise would be best categorized in the less emotive category "procedural necrosis" rather than "myocardial infarction."

Consequently, I agree with the recommendation of Lippi and Cervellin that a change in the arbitrary threshold for procedural infarction when measuring troponin after PCI would be useful. This change in the "universal definition" may allow us to steer safely between Scylla and Charybdis toward a better understanding of revascularization injury and perhaps, ultimately, to the destination of abolishing it.

***Adrian Banning, MD**

*John Radcliffe Hospital
Oxford Heart Centre
Headley Way
Headington
Oxford, Oxfordshire OX3 9DU
United Kingdom
E-mail: adrian.banning@orh.nhs.uk

doi:10.1016/j.jacc.2011.03.029

REFERENCES

1. van Gaal WJ, Arnold JR, Testa L, et al. Myocardial Injury Following Coronary Artery Surgery Versus Angioplasty (MICASA): a randomised trial using biochemical markers and cardiac magnetic resonance imaging. EuroIntervention 2011;6:703–10.
2. Porto I, Selvanayagam JB, van Gaal WJ, et al. Plaque volume and occurrence and location of periprocedural myocardial necrosis after percutaneous coronary intervention: insights from delayed-enhancement magnetic resonance imaging, thrombolysis in myocardial infarction myocardial perfusion grade analysis, and intravascular ultrasound. Circulation 2006;114:662–9.
3. Lim CC, van Gaal WJ, Testa L, et al. With the "universal definition," measurement of creatine kinase-myocardial band rather than troponin allows more accurate diagnosis of periprocedural necrosis and infarction after coronary intervention. J Am Coll Cardiol 2011;57:653–61.
4. Selvanayagam JB, Porto I, Channon K, et al. Troponin elevation after percutaneous coronary intervention directly represents the extent of irreversible myocardial injury: insights from cardiovascular magnetic resonance imaging. Circulation 2005;111:1027–32.
5. Cavallini C, Verdecchia P, Savonitto S, et al. Prognostic value of isolated troponin I elevation after percutaneous coronary intervention. Circ Cardiovasc Interv 2010;3:431–5.

"Universal Definition" Methodology and Conclusions Are a Concern

We congratulate Lim et al. (1) on their recent paper assessing this area relevant to clinical practice, especially in light of sensitive cardiac troponin (cTn) assays. However, we have important concerns over the methodology and conclusions.

First, it seems inappropriate to use an insensitive test, late gadolinium enhancement cardiac magnetic resonance (CMR), as a gold standard diagnosis, to compare a sensitive test, cTn, with a moderately sensitive test, creatine kinase-myocardial band (CK-